

# **Development of Algorithms and Strategies for Monitoring Chlorophyll and Primary Productivity in Coastal Ocean, Estuarine and Inland Water Ecosystems**

Semi-Annual Technical Report: NAS5-96063

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## **Summary**

This is the semi-annual technical report for the period January through June 2003 for the Execution Phase of my MODIS Instrument Team investigator project. The objectives of this work are:

- Establish a protocol for developing regional or site-specific bio-optical algorithms for coastal “case 2” waters.
- Prescribe a protocol for “stitching together” local or site-specific algorithms.
- Demonstrate these protocols in two coastal seas: the Gulf of Maine/Mid-Atlantic region, and the Yellow Sea/East China Sea region.
- Develop a strategy for monitoring coastal oceans, estuaries, and inland waters.

This report reflects the efforts of a research team consisting of myself, two staff scientists (Dr. Mark Dowell and Timothy Moore), one Ph.D. student (Seung-Hyun Son), and one Masters student (Michael Novak).

## Papers published or submitted:

1. Mahadevan, A. and J.W. Campbell. “Biogeochemical Variability at the Sea Surface: How it is linked to process response times.” Chapter in press, to be published in *Scales in Ecology*, CRC Press, Laurent Seuront, editor.
2. Campbell, J.W., T.S. Moore, M. D. Dowell, “Observing Dynamic Bio-optical Provinces: A Global Study,” (submitted to JGR, Aug. 2001, accepted subject to revisions July 2002). This paper which was listed in previous technical reports has been withdrawn. We intend to revise the paper using MODIS data and a different approach (see January 2003 Technical Report).
3. Salisbury, J. E., J. W. Campbell, E. Linder, L. D. Meeker, F.E. Muller-Karger, and C.J. Vorosmarty, “The influences of discharge and winds on suspended sediment distributions in the Northern Gulf of Mexico.” (in revision, DSR, July 2003)
4. Carder, K. L., F.R. Chen, J.P. Cannizzaro, and J.W. Campbell. “Performance of MODIS Semi-analytic Ocean Color Algorithm for Chlorophyll-a.” (in press, *Adv. Space Res.*, Apr. 2003)

#### Presentations January - June 2003:

7. Dowell, Mark D., Jeffrey Runge, and Janet Campbell. "Characterizing the global distribution and nature of the rate of algal loss in pelagic marine ecosystems." Poster presented at the IGBP Oceans Conference, Paris, France, January 2003.
8. Christopher Wason, Matt Giguere, Maeghen Driscoll, Lisa Seydewitz, Dan Hocking, Erin Faltin John Baker, Michael Novak, Shane Bradt, Janet Campbell, Richard Blakemore, Alan Baker. "Project Lake Watch: On Golden Pond for Lake Truthing Landsat and MODIS." This was one of three posters presented at the ASLO Aquatic Sciences Conference, Salt Lake City, Utah, Feb. 2003. (*This poster won a blue ribbon for merit in the student poster competition.*)
9. Son, Seung-Hyun, Janet W. Campbell, Mark D. Dowell, Il-Ju Moon, and Sinjae Yoo. "Classification of Well Mixed and Stratified Waters in the Yellow and East China Seas." Poster presented at the Ocean Color Science Team Meeting, Miami, Apr. 2003.
10. Son, Seung-Hyun, Janet Campbell, Mark Dowell, and Timothy Moore. "Decadal and Inter-annual Variations in the Yellow and East China Seas Revealed by Satellite Ocean Color Data (1979-2002). Poster presented at the JGOFS Open Science Conference, Washington, DC, May 2003. (*This poster won the Best Student Poster in its category.*)

#### **Case 2 Algorithm Protocol Development**

There are two areas of algorithm development that are addressed in this project. One is the bio-optical algorithm that retrieves chlorophyll and other optically-active constituent concentrations. The second area is the primary productivity algorithm.

##### Bio-optical algorithms

We have not made progress in this area since the January 2003 technical report. However, as a result of a class on global marine ecosystems taught by Mark Dowell last fall, a manuscript is being prepared which uses MODIS data. The abstract is as follows:

#### **Global maps of the carbon:chlorophyll ratio using an empirical relationship: initial results and consequences for marine ecosystem modeling**

Timothy S. Moore and Mark D. Dowell

**Abstract.** Global carbon:chlorophyll maps are generated from satellite products (SST and Chl), modeled variables (mixed layer depth), and climatological interpolated fields ( $\text{NO}_3$ ) using an empirical model (Cloern et al, 1995). The resulting maps show large spatial and temporal variability in the range of 10 to more than 200 gC:gChl. The variability of this ratio can have profound effects in global marine ecosystem models which assume a constant ratio. The empirical

relationship is sensitive to the half-saturation parameter for nitrate ( $K_n$ ), which also has a large degree of variability. Despite these shortcomings, it is now possible to characterize the dynamic behavior on a global scale of an important variable in global carbon transfer modeling.

#### Primary productivity algorithms

My graduate student (Seung-Hyun Son) is now spending two months at the Bedford Institute of Oceanography, Halifax, Nova Scotia, working under the supervision of Dr. Shubha Sathyendraneth. This trip was supported by a fellowship from the International Ocean Colour Coordinating Group (IOCCG). He has produced primary productivity maps of the Yellow and East China Seas using MODIS chlorophyll and SST data. This will be part of his dissertation.

No further progress has been made in this area.

#### **Demonstration in Gulf of Maine and Yellow Sea Regions**

We are continuing to assemble a database of in-situ bio-optical data for the two demonstration sites: Gulf of Maine and Yellow Sea.

- Gulf of Maine. We have received a shipment of all the MODIS Collection 4.0 granules for the northwest Atlantic Continental Shelf (between Nova Scotia and Cape Hatteras, NC). We have remapped all the granules to provide daily images, and then formed weekly (8-day) averages (e.g., fig. 1). These data will be served by Web-COAST, a web-based data and information server funded by NOAA as part of the Center of Excellence for Coastal Observation and Analysis (COOA). Current plans are to provide remapped chlorophyll and SST data. We will post weekly composite browse images on Web-COAST, but will make all the data available via ftp or other media. Other details of our plans are described in our January 2003 report. In addition, Mark Dowell has begun a series of monthly cruises to gather bio-optical and primary productivity data for parameterizing algorithms. These cruises are supported by the COOA center.

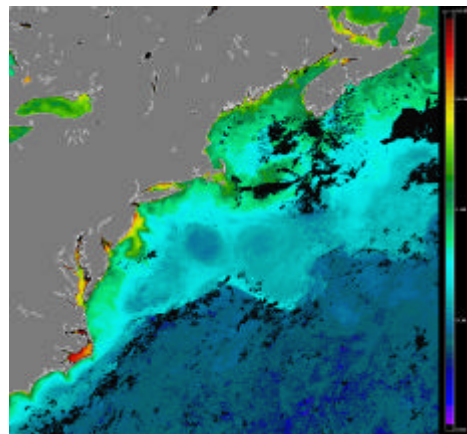


Fig. 1. Standard mapped image of the MODIS SeaWiFS-analog Chlorophyll for the Northeast. This image was produced from MODIS Terra data acquired between August 5 and August 12, 2001.

- Yellow and East China Seas. This is the thesis work of Seung-Hyun Son, who expects to complete his Ph.D. dissertation in late 2003. His work is described in the January 2003 technical report. At the Bedford Institute this summer, he is parameterizing primary productivity algorithms using a database of P-I model parameters, and vertical profiles of chlorophyll and light.

## **Development of Monitoring Strategies**

No further progress has been made in this area. The establishment of the Web-COAST server and the reprocessing of MODIS data will facilitate progress in this area.

## **Support of MODIS Ocean Team Activities**

We sponsored a MODIS Ocean Data Products workshop at UNH on February 3-4, 2003. This workshop provided a comprehensive summary of the status of the MODIS Ocean data products to an audience of 70 people (50% from New England, but others from as far away as Germany, England, The Netherlands, Canada, Puerto Rico, and California). Most of the audience were from academic institutions, but there were representatives from private industry and government laboratories as well. Members of the MODIS Ocean Science team and the Goddard DAAC covered step-by-step details of the processing, distribution, analysis, and interpretation of the MODIS Ocean variables. The workshop also included a hands-on computer tutorial that took participants through details of data ordering, reprojection, reformatting and other technical tools.

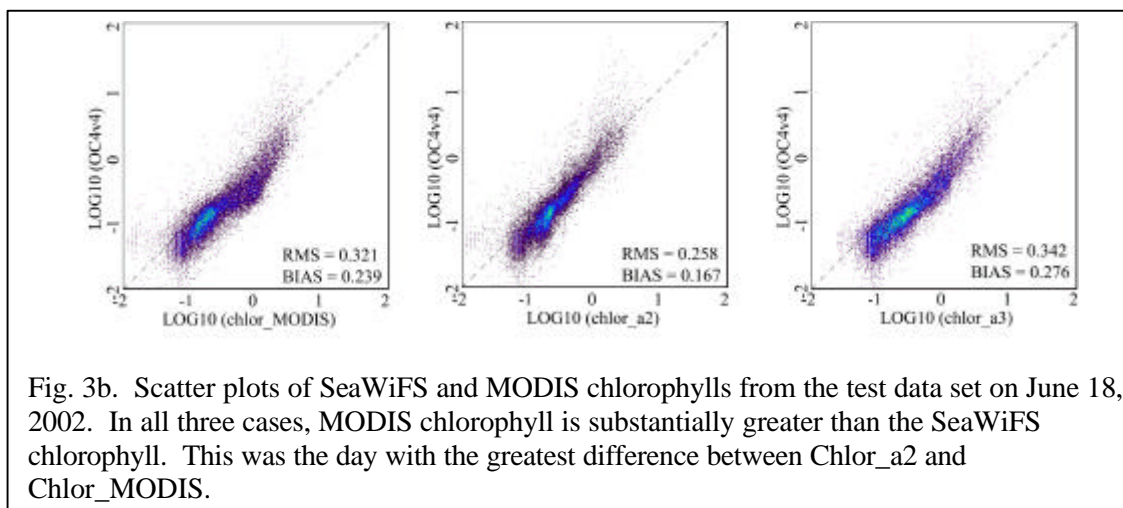
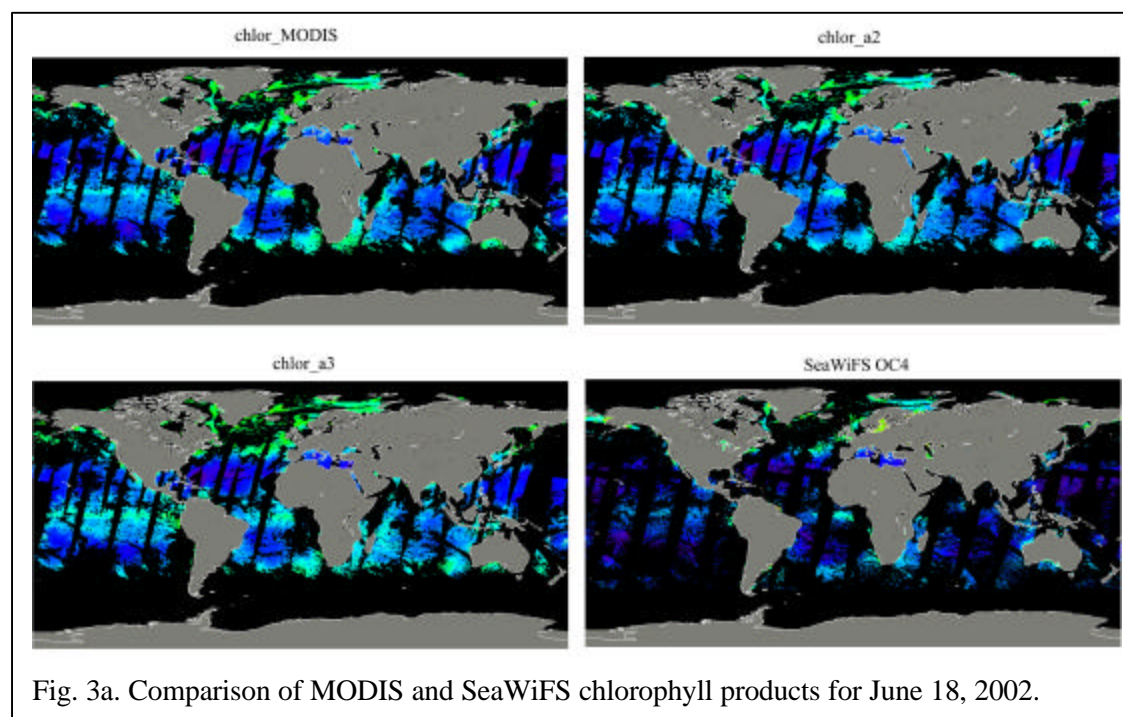
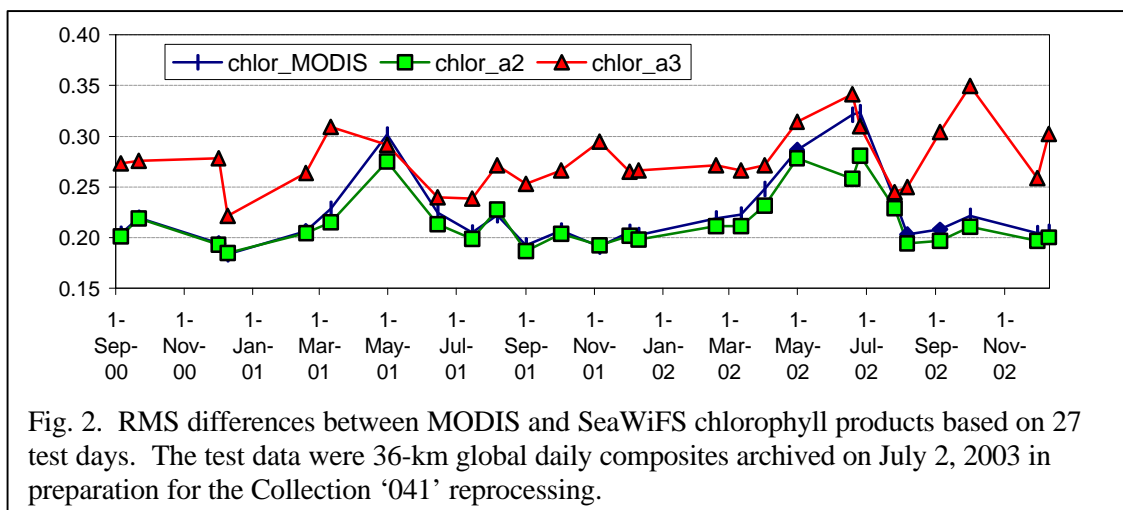
During this reporting period, we have been active in the evaluation and validation of MODIS products in support of new codes to be applied to MODIS data beginning in August 2003. The newly processed data will be designated Collection '041' to distinguish it from Collection '040' that was processed last year. The MODIS Oceans Team has held weekly teleconferences to discuss issues raised during this phase. We have continued to evaluate MODIS chlorophyll products and compare them with SeaWiFS chlorophyll data acquired at the same location and on the same day. Comparisons were recently made for a series of 27 global (36-km) daily chlorophyll products (figs. 2-4).

Chlor\_a2, the SeaWiFS Analog chlorophyll, had the lowest RMS difference from SeaWiFS, but differed systematically. In fact, all three MODIS chlorophyll products produced for the Collection '041' are systematically higher than the SeaWiFS chlorophyll on nearly every test day. Figures 3 and 4 illustrate this for two days in which Chlor\_a2 differed from Chlor\_MODIS (June 18, 2002) and from Chlor\_a3 (October 1, 2003). We are still evaluating these results.

## **Progress in Related Areas**

During this reporting period, I served as an associate editor for a series of papers presented at the World Space Congress 2002 in Houston, TX, October 2002, which are to appear in *Advances in Space Research*. There were 11 papers reviewed and 10 accepted for publication. A subcontract to Erickson Technology Solutions of Boothbay Harbor, Maine, was given to provide logistical support for this editorial work, and for the MODIS Ocean Data Products Workshop held in February 2003.

A proposal entitled "Refinement and Maintenance of the SeaWiFS-analog Chlorophyll Algorithm: Insuring Continuity of the Climate Data Record for Chlorophyll" was submitted to the Aqua-Terra "Recompete" NRA in April 2003.



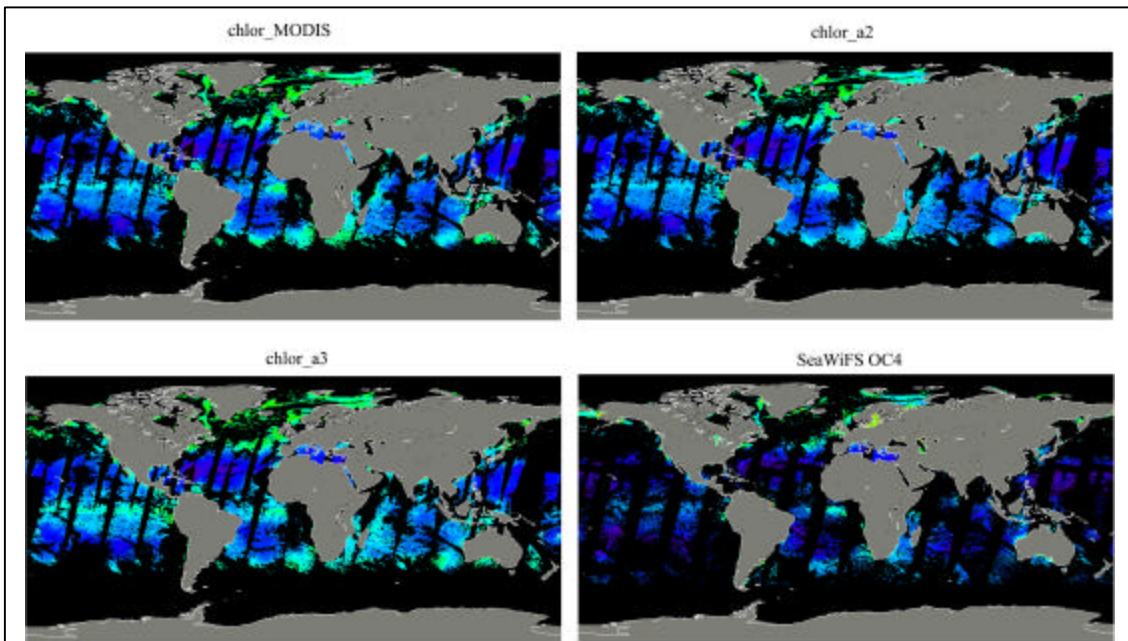


Fig. 4a. Comparison of MODIS and SeaWiFS chlorophyll products for October 1, 2002.

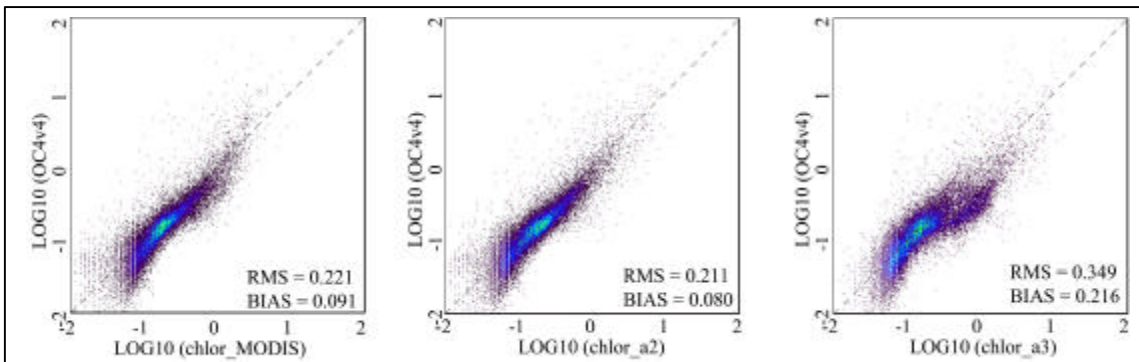


Fig. 4b. Scatter plots of SeaWiFS and MODIS chlorophylls from the test data set on October 1, 2002. As in Fig. 3, the MODIS chlorophylls are substantially greater than the SeaWiFS chlorophyll. This was the day with the greatest difference between Chlor\_a2 and Chlor\_a3.